STATE OF OHIO
MICHAEL V. DISALLE, Governor
DEPARTMENT OF NATURAL RESOURCES
HERBERT B. EAGON, Director
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Information Circular No. 30

DATING OHIO'S GLACIERS

By

Jane L. Forsyth

COLUMBUS
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Just as the history of mankind is divided into periods such as the Renaissance or Middle Ages, so is the history of the earth divided into periods which, taken together, constitute what is called a "geologic time scale". Unlike the history of man, very little is known about the exact age in years of the different subdivisions making up this geologic time scale except that they are very long and all greatly antedate earliest human history. The age of most geologic events is known to be on the order of hundreds of millions of years, but the exact number of years generally is known so poorly that the ages of the events are usually given only in their relation to other geologic events. Only in a very few areas has it been possible to obtain a geologic age that is more accurate, determined from laboratory analyses of minerals containing radioactive elements such as uranium.

METHOD OF DATING

For the most recent part of the youngest subdivision of the geologic time scale, the Pleistocene epoch or time of the Ice Age, however, a method has been developed for determining the exact date of an event in years. This method, called the radiocarbon method, is based on the fact that a radioactive isotope of carbon, which has an atomic weight of 14 (carbon-14) rather than the usual 12, is present in an extremely minute but constant ratio in the earth's atmosphere. This radioactive carbon (or radiocarbon) is created when normal nitrogen atoms (atomic weight 14) in the atmosphere are struck by rapidly moving neutrons from the cosmic rays bombarding the earth's upper atmosphere. When a neutron strikes a nitrogen atom, it knocks one of the positively charged protons out of the nucleus of the nitrogen atom, replacing it, so that the electric charge on the atom is changed. This atom, which is now radioactive carbon, is unstable; sooner or later a negatively charged electron will be given off, converting the atom back into stable nitrogen again. This process, like all other radioactive processes, proceeds at a constant rate measured according to the half-life of the substance. The half-life of radiocarbon is 5568 ± 30 years; this means that half of the radioactive carbon in a closed system will have reverted back to nitrogen after about 5500 years, and after another 5500 years, half the remaining radiocarbon also will have reverted. This is shown diagrammatically in figure 1. The organism referred to in figure 1 might be a piece of wood, shell, bone, or tissue, though almost all determinations in Ohio are made on wood. Since the initial amount of radiocarbon is extremely small (only one atom in a trillion [million million] carbon atoms is radioactive), it is very difficult to measure; only with the delicate modern electronic means now available is it possible at all.

In living things, this ratio (one to one trillion) of radioactive to stable carbon remains the same because both kinds of carbon, in amounts determined

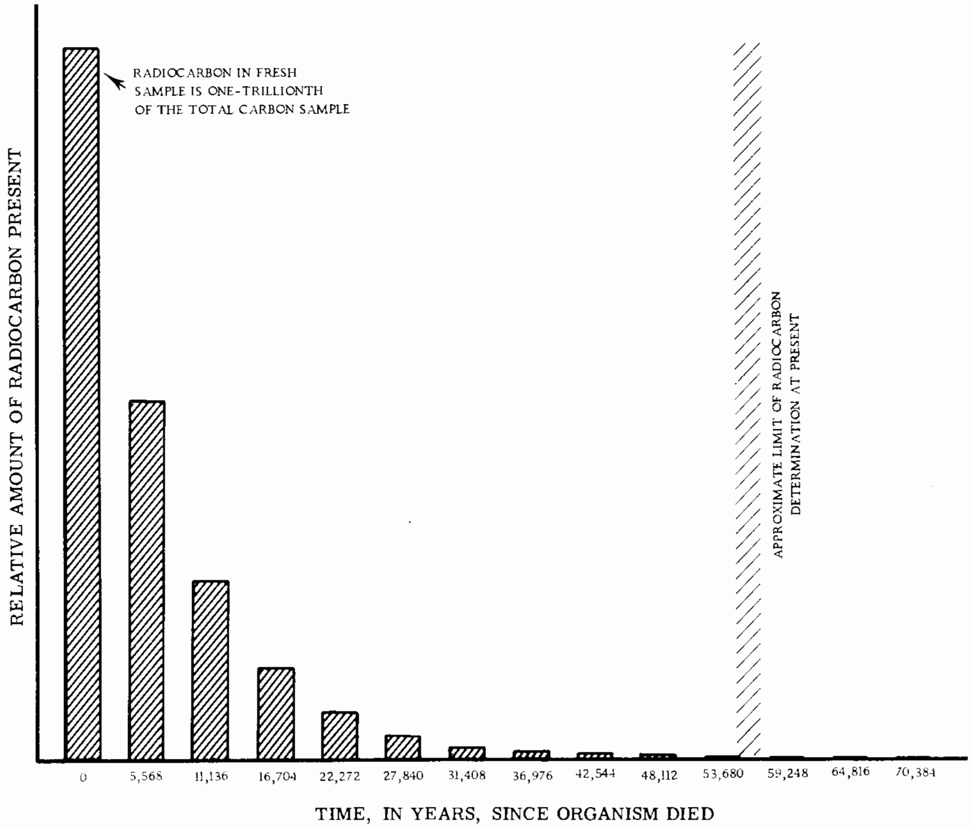

Figure 1. - Graph showing decreasing amount of radiocarbon present in dead organism.

by this ratio, are always being added to the organism by the growth processes. When an organism dies, however, the growth processes cease, new carbon of both types ceases to be added, and a closed system results. Thus the radiocarbon content, which was only a minute percentage of the total carbon present when the organism died (one atom out of every trillion atoms), diminishes to less and less, a half of the remaining radiocarbon being lost about every 5500 years. If the amount of radiocarbon lost from any dead organism of unknown age can be measured, therefore, the time since the organism died can be determined, thus providing a measure of the age of the deposit containing this organism. For example, determining the age of a tree killed by an advancing glacier also dates the time of advance of the ice. At the present time, this method of age determination is good only to as far back as about 45,000 years; the amount of radiocarbon in samples older than this is so extremely small that, even with the modern, extra-sensitive laboratory equipment now in use, it cannot be measured. This limit permits dating of only the last part of the Wisconsin stage (most recent of four stages) of the Pleistocene.

The process by which the age of a piece of Pleistocene wood is determined is not especially complicated, but it demands extreme accuracy because the amount of radiocarbon being measured is so slight. After treatment with acids to remove foreign materials (fig. 2), the wood is converted by controlled combustion into gaseous carbon dioxide, which is first purified and then reduced to elementary carbon. The actual process of dating comes next.

The radioactivity of the carbon sample is measured by a very sensitive Geiger counter, shown in figure 3, which simultaneously measures the radioactivity of a sample of "dead" carbon, usually coal, to give a "background"

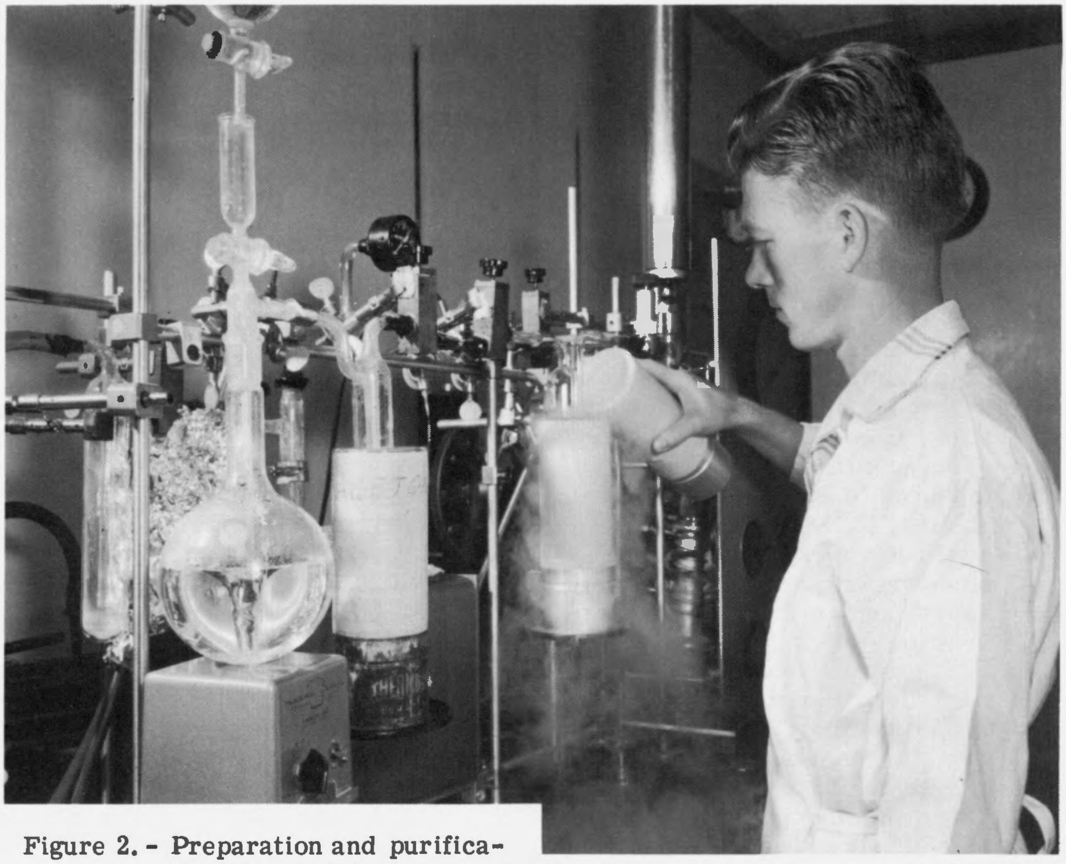

Figure 2. - Preparation and purification of a Pleistocene wood sample.

Figure 3. - Insertion of purified carbon sample into Geiger counter for radiocarbon analysis.

Photos courtesy of Humble Oil and Refining Company.

count, or basis for determining the true value of the Pleistocene sample. The Geiger counter is encased within thick walls of steel to reduce, as much as possible, the effect of extraneous radiation. In addition, a ring of smaller Geiger counters surrounds the apparatus to detect cosmic radiation. These counters do not stop the cosmic rays, but being sensitive to them, turn off the main Geiger counter for the instant when the cosmic rays are passing through, so that the rays will not affect the results. For samples which are extremely old, the process must be run a very long time to show any difference in count between the Pleistocene sample and the "dead" carbon. (This scientific data has been taken mostly from the report on radiocarbon dating by Briggs and Weaver, 1958. More detailed information regarding the theory and method occurs in Libby, 1955, and Libby, 1956.)

RESULTS OF DATING IN OHIO

Many radiocarbon determinations have been made on samples from Ohio. In most cases the sample has been wood which represents a part of a tree which died only shortly before the advancing glacier moved over it (Burns, 1958). Locally, wood fragments are so abundant in Ohio's glacial deposits as to suggest that a whole forest was overrun by the ice, such as can be observed in places in Alaska today (fig. 4) (Goldthwait, 1959). This wood, buried in the glacial till (pebble clay), may be observed today where stream erosion or man's construction exposes it (fig. 5). Occasionally, snail shells, mastodon tusks, or other organic matter have been used for the tests, but they have given less satisfactory results than has wood.

Not all wood found in glacial deposits is sent to the laboratory for dating; these determinations are expensive and time consuming, so only that wood which will be the most informative is analyzed. For Pleistocene wood to be informative, its exact occurrence must be known, both as to the geographic location and the relation of the individual wood-bearing layer to the geology of the region (interpreted from the complete sequence of geologic layers and from the geology of the surrounding area, something that only a trained geologist can do). Merely

Figure 4. - Modern spruce forest being invaded by modern glacier (Taku) in Alaska. Photo by W. O. Field.

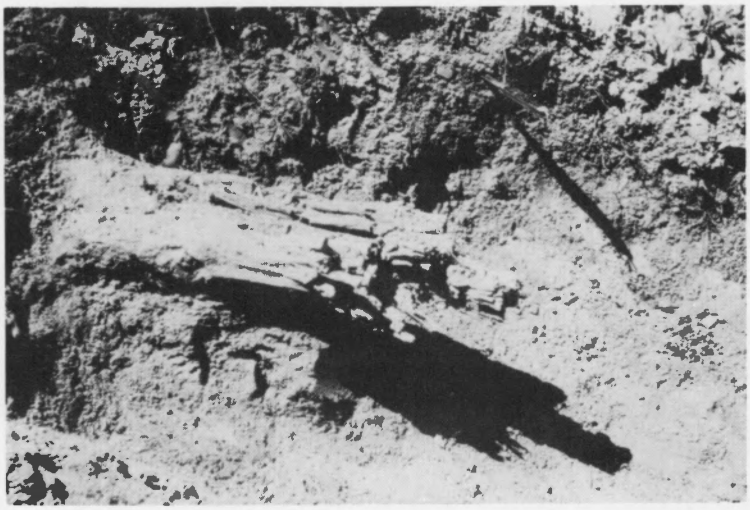

Figure 5. - Glacial-age log incorporated in deposit of glacial till ("late" Wisconsin), exposed in the B. and O. Railroad cut 2 miles south of Sidney, Ohio.

establishing the age of a piece of wood, which after all, is consumed in the laboratory procedure, is of little value. But when the date of a piece of wood can be shown to be also the date of a specific geologic event, such as the advance of the ice at a given place in Ohio, then analysis of the wood becomes very important. When many such dates are known, these events can be assembled into a chronological sequence, so that the whole history of the last advance of the glacier into Ohio can be interpreted.

Many locations providing pieces of Pleistocene wood in Ohio have been reported by people who are not professional geologists: farmers, boy scouts, gravel-pit operators, well drillers, soils mappers, and others; but a great many of these wood samples were not satisfactory for age determination because of inadaquate geologic and geographic information regarding their occurrence. Most of those samples, however, for which accurate information was available have been dated. This circular has been prepared to show the location of these samples in Ohio (fig. 6), their radiocarbon ages (table 1), and the significance of these ages (fig 7; also see Flint, 1955; Flint, 1957; and Goldthwait, 1958).

The many radiocarbon determinations from Ohio can be divided into three main groups, representing three main events (Goldthwait, 1958), which are shown in separate groups in table 1. The oldest series of dates are not actual numerical values; they are minimum figures indicating that no measurable amount of radiocarbon was found in the sample. (The actual numbers following the symbol " " on the chart vary. This is because they represent the oldest positive age that the laboratory could have identified if any measurable radiocarbon had been present. This value has increased as laboratory procedures have been refined, so the larger numbers following the symbol ">" on this chart represent more recent determinations.) Of the deposits from which these oldest samples have been collected for dating, most have been interpreted on the basis of field evidence to be of probable Wisconsin age. If this interpretation is correct, it is likely, especially on the basis of information from Europe, that the addition of 10,000 to 30,000 years to the value given might come close to the true age. All the rest of the radiocarbon dates listed are actual values.

The next series of dates identify stages in the latest advance of the Wisconsin glacier across Ohio. In addition to the actual value, these dates all

Figure 6.- Map showing locations and dates of Pleistocene wood samples from Ohio that have been analyzed by the radiocarbon method. Statistical errors and laboratory numbers for these dates are not shown here, but appear in table 1.

TABLE 1. - RADIOCARBON DATES IN OHIO

Location	Date (in years B. P.[1])	Lab. No.[2]
Dates of nonglacial materials which originated before the last advance of the glacier[3]		
N. Hampton, Clark Co.	>40,000	W-152
Kirkwood, Shelby Co. (Brush Creek)	>37,000	W-415
Gahanna, Franklin Co.	>37,000	W-263
Clarksville, Clinton Co.	>37,000	Y-473-1
Germantown, Montgomery Co.	>34,000	W-96
Dates showing the last advance of the glacier southward over Ohio in the Scioto lobe		
Cleveland, Cuyahoga Co. (Cleveland Sand and Gravel Co.)	24,600±800	W-71
Columbus, Franklin Co.	23,000±850	Y-449
Harrisburg, Pickaway Co.	21,600±1000	W-127
Fairborn, Greene Co.	21,600±400	W-648
Newark, Licking Co. (Kaiser)	21,400±600	W-88
Cuba, Clinton Co.	18,500±420	Y-448
Chillicothe, Ross Co.	18,050±400	W-91
Anderson, Ross Co.	18,000±400	W-331
Dates showing the last advance of the glacier southward over Ohio in the Miami lobe		
Sidney, Shelby Co.	23,000±800 22,480±800	W-188 W-356
Kirkwood, Shelby Co. (Brush Creek)	22,000±1000	W-414
Southern Hills, Montgomery Co. (Hole's Creek)	20,700±600	W-37
Westchester, Butler Co.	20,500±800	W-304
Oxford, Butler Co.	19,980±500	W-92
Hamilton, Butler Co.	19,100±300 18,750±300	W-724 W-738
Darrtown, Butler Co.	16,560±230	Y-450
Dates of nonglacial materials which originated after the last retreat of the glacier		
Edon, Williams Co. (Ohio Turnpike)	14,300±450	W-198
Cleveland, Cuyahoga Co. (Canal Sand and Gravel Co.)	13,600±500	W-33
Parkertown, Erie Co. (Ohio Turnpike at Rt. 4)	12,920±400	W-430
Columbus, Franklin Co. (Northern Lights Shopping Center)	11,480±160	Y-526
Bellevue, Sandusky Co.	12,800±250	Y-240
West Jefferson, Madison Co. (Orleton Farms)	9,600±500	M-66
Castalia, Erie Co.	8,513±500	C-526

1. B. P. means "before present".
2. Letter denotes radiocarbon laboratory: W-U.S.G.S., Washington; Y-Yale Univ.; M-Univ. of Michigan; C-Univ. of Chicago. (Earlier values on some of these sites, made when results were less accurate, are not included in this list; see Goldthwait, 1958.)
3. For all these samples, the laboratory results showed no radiocarbon. The variation in actual number in these dates represents the greatest age that could have been read at the laboratory if analyzable radiocarbon had been present. In general, the larger values represent the more recent determinations.

have suffix numbers beginning with the symbol "±" which indicates the laboratory's estimate of the statistical error in the date. Each date in this group represents a piece of wood which was part of a tree growing in Ohio before the advancing ice buried it in the glacial deposit from which it was collected. Most of the wood is spruce (Picea) (Burns, 1958), which today grows in central Canada. From this fact it is inferred that a climate more like that of central Canada today was present in a broad belt around the front of the advancing ice at that time in Ohio (Burns, 1958; Goldthwait, 1959).

The youngest series of dates, the bottom group in table 1, come from wood and shells taken from postglacial materials: muck, marl, and lake silts. Because these samples come from nonglacial materials, these dates represent some indeterminate moment within postglacial time and thus provide only a minimum value for the length of time since the glacier finally retreated permanently to the north out of Ohio.

It is mainly from the dates of the second group that the glacial story of Ohio is interpreted. As the ice advanced southward, it encountered the highland east of Bellefontaine; this caused the glacier to divide, forming two ice lobes, the Scioto lobe in central Ohio and the Miami lobe in western Ohio, which advanced at somewhat different rates. A sequence of estimated ice-front positions, inferred from the radiocarbon dates of this second group, is shown in figure 7. Other lobes were formed in northeastern Ohio, but are not considered here because practically all the radiocarbon determinations in Ohio come from wood samples collected in the western part of the State. Shortly after the ice front had reached its southernmost position near Cincinnati (Miami lobe) and Chillicothe (Scioto lobe), it began to retreat back to the north. There is no radiocarbon record of this retreat; forests are not overridden by a retreating glacier.

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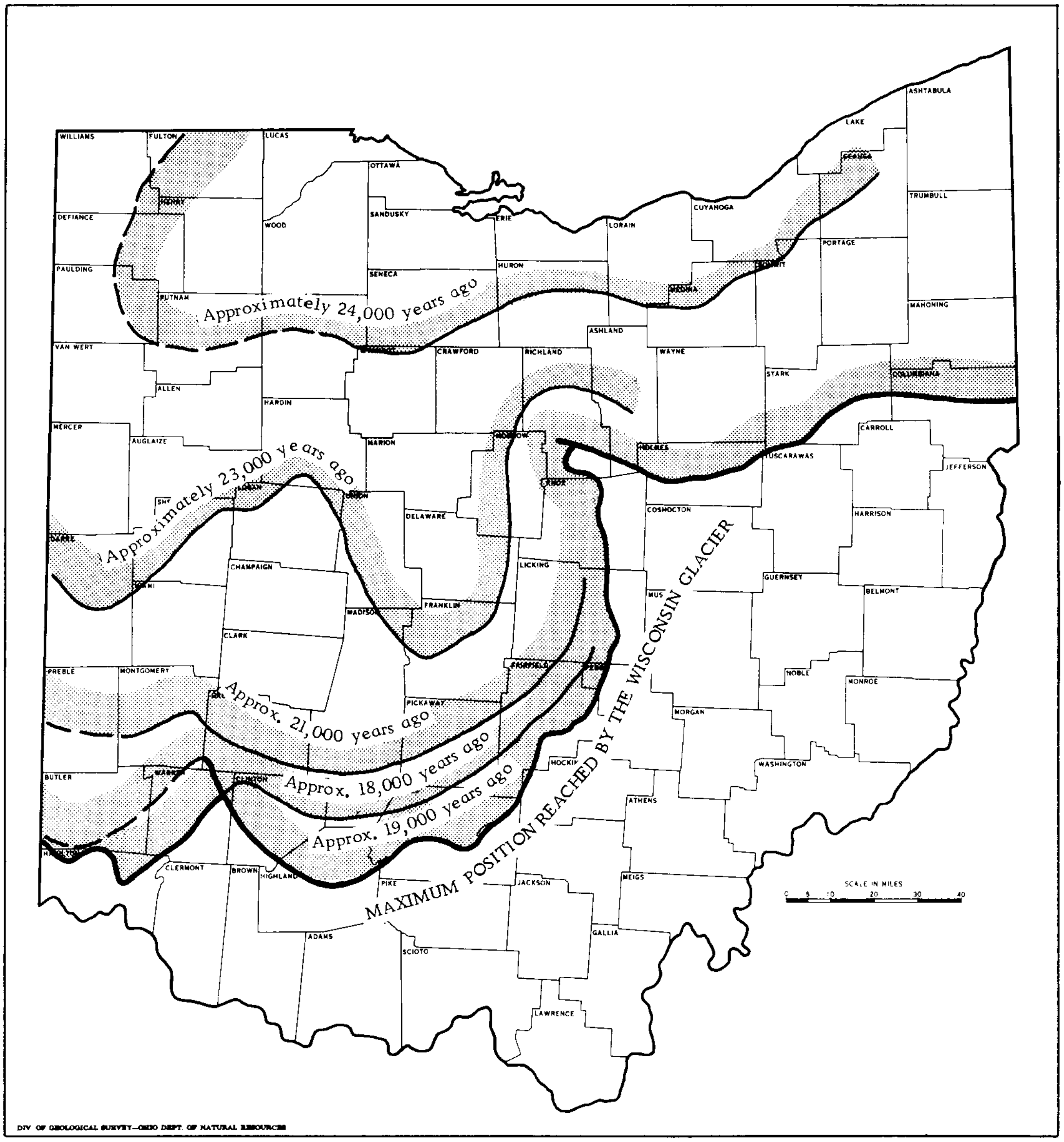

Figure 7. - Succession of estimated positions of the ice front as the last Wisconsin glacier advanced south across Ohio, based on dates from wood collected from the base of the till deposit left by the glacier.

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